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ABSTRACT

This is a report of the science program under development by the Individually Prescribed Instruction (IPI) project. IPI is developing several elementary curricula (e.g. reading, mathematics) as well as science, and all are characterized by six IPI individualization goals: (a) every student makes regular progress towards mastery of instructional content; (b) every student proceeds to mastery of instructional content at an optimal rate; (c) every student is engaged in the learning process through active involvement; (d) the student is involved in learning activities that are wholly or partially self-directed and self-selected; (e) the student plays a major role in evaluating the quality, extent, and rapidity of his progress towards mastery of successive areas of the learning continuum; (f) different students work with different learning materials and techniques of instruction adapted to individual needs and learning styles. In addition to these individualization goals, the following three goals further delineate the purpose of IPI Science: (a) every student develops positive attitudes toward science and scientist; (b) every student becomes skillful in using the processes of scientific inquiry; (c) every student acquires a foundation of scientific literacy. (BR)

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IPI SCIENCE: A TEACHING REVOLUTION IN THE MAKING

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In the science laboratory-classroom at Oakleaf Elementary School, located in suburban Pittsburgh, Pa., an experimental instructional program is operating today that may well have a revolutionary impact on science teaching in this country. For the first time, the oft-expressed dream of a truly individualized science program is becoming a reality at Oakleaf.

Looking in on the children in the science room, we see them intently engaged in many different activities. One boy is working on a lesson about linear measurement. In front of him is a kit of materials which he manipulates as he receives directions from a tape recording. A girl in the next carrel is learning how to classify objects by sorting them according to their properties. Earphones on her head, she is also listening to instructions from a tape recording. Another investigator is leaving his laboratory station to go outside to explore an extension of his lesson on shadows. In another carrel a learner is taking a pre-test for a unit on magnets; after he completes the pre-test, the aide will score it and the teacher will prescribe a course of study for the child. As the laboratory activity continues, students in their carrels and in other areas of the room are in many phases of science learning. They are securing lesson materials, taking pre and post tests, and receiving help from the teacher and the aide.

The teacher in this lab may be leading a discussion with a small group of students who have just completed or are now involved in a unit on volume. In these group sessions, the students can interact with one another and share the experiences they are having in the self-learning situations. The students are finding out that they can apply what they have learned to new problems. In many instances, students in this science environment are exploring things on their own. A boy who has just finished his lab lesson is now puzzling with a mercury puzzle. A little girl peers intently into the terrarium while listening to a tape of information and questions about the box turtle. These students seem to be responsible and able to learn independently about their environment. As one looks in on these small-fry first and second-grade investigators, the total picture is highlighted by busy involvement, sustained interest, and excitement.

The scene we've described recurs continually in the science room at Oakleaf, a public elementary school associated with the Learning Research and Development Center (LRDC) at the University of Pittsburgh in a major educational experiment. In September 1964, LRDC and Oakleaf initiated a new system of Individually Prescribed Instruction (IPI) for the school's 270 students. Today, all of Oakleaf's students are learning mathematics and reading at their own individual pace under the IPI system. Pupils in the early grades are also taking IPI programs in spelling and science. IPI represents a significant innovation in education because it is one of the first suc-

Free to learn at his own pace, an IPI student focuses intently on his unit.

Emphasizing self-learning, IPI Science at the minimum furnishes students with a solid core of scientific literacy, methods, and attitudes.

ssful operations of individualized instruction on a systematic basis throughout an entire school from kindergarten through the sixth grade[1].

Individualization Goals of IPI

The IPI system is designed to meet the needs of the individual learner. Each student can progress in an IPI curriculum at a rate which is individually adapted to his learning requirements. As the student progresses thro[illegible] an IPI curriculum in this way, we expect that he develop the necessary skills of self-learning to become a productive learner beyond his school experience. Since the student regularly experiences successful learning in IPI, he will readily form favorable attitudes towards the learning environment and develop a positive outlook on educational challenges that he must confront in further schooling and in his future life. These long-term aims set the framework for the individualization goals of IPI.

The following paragraphs give statements of the six IPI individualization goals, together with some amplifying comments.

A. *Every student makes regular progress towards mastery of instructional content.* By demonstrating mastery of the behavioral objectives upon which lessons and instructional materials are based, the student may move through an IPI curriculum in a systematic way.

B. *Every student proceeds to mastery of instructional content at an optimal rate.* The rate at which a learner proceeds is very important in IPI. Because student learning is *not* treated on a grade level or class basis, but is individualized, each student can find a rate of learning that is optimal for his needs. Both the rapid and the slow learner benefit from this arrangement, since each individual can proceed at a personally comfortable rate without anxiety.

C. *Every student is engaged in the learning process through active involvement.* Involvement develops a zest for learning that becomes the foundation for future learning. In an IPI curriculum, the student has first-hand experiences with many types of stimulus inputs from a dynamic educational environment.

D. *The student is involved in learning activities that are wholly or partially self-directed and self-selected.* As the learner progresses through an IPI curriculum, he is encouraged to become self-directed and to select his own learning activities. In many instances, the student can best prescribe his own instruction. Self-prescription helps to create in the student the responsibility and awareness of working toward desired outcomes in any learning situation. Self-directed and self-selected activities may involve groups of students. These group learning situations add a great deal of flexibility to an IPI curriculum.

E. *The student plays a major role in evaluating the quality, extent, and rapidity of his progress towards mastery of successive areas of the learning continuum.* This goal of student co-evaluation complements the foregoing student self-direction goal. If a student is to direct his own learning effectively, he needs adequate evaluative feedback about his progress, his achievements, and his deficiencies. The most direct means by which evaluation can enhance a student's learning is for him to play a major role in the evaluation process. Beginning early in an IPI curriculum, the student has many opportunities to judge the quality of his performance, and, as he continues in IPI, his competence in evaluating his own work can increase to a level where he can make diagnostic judgements that are valid and useful to himself. An underlying intent of student co-evaluation is to eliminate the dread and anxiety which frequently accompany testing and evaluation procedures in many schoolrooms. Instead of evaluation as something exterior to the student, something always mysterious and often theatening, IPI employs student co-evaluation in a positive supporting relationship with the learning of each individual.

F. *Different students work with different learning materials and techniques of instruction adapted to individual needs and learning styles.* Different techniques of instruction are required to help meet the needs of the individual learner. Research into the area of learning styles indicates that students have a wide range of learning abilities and needs. The different modes of instruction available in an IPI curriculum help the student maintain a reasonable rate of learning, instead of falling behind because of some deficiency in the materials provided for a particular learning situation. Alternative modes of instruction allow a student to pursue a pathway of learning that is different from that of his fellow students but, nevertheless, to obtain the same objective in the IPI curriculum. The availability of alternative modes of instruction is one of the keys to success of a truly individualized program.

IPI Science

The six IPI individualization goals characterize all of the IPI curricula now under development at Oakleaf. IPI Science, currently available to Oakleaf's children in kindergarten and grades one through three, is designed to attain these goals. However, in addition to these individualization goals, the following three instructional goals further delineate the purpose of IPI Science:

A. Every student develops positive attitudes toward science and scientists. [AFFECTIVE GOAL]

B. Every student becomes skillful in using the processes of scientific inquiry. [INQUIRY GOAL]

C. Every student acquires a foundation of scientific literacy [SCIENTIFIC LITERACY GOAL]

These three instructional goals imply the scope of IPI Science the attitudes, inquiry skills, and understandings that are to be developed by the student through his science learning experiences. It is convenient to describe the scope as a set of terminal behaviors, which should be observable in the student who has attained the instructional goals. The terminal behaviors presently delineated

for IPI Science are given below. While it is likely that some of these statements will be modified as curriculum development proceeds, the following set of terminal behaviors gives an accurate description of the scope of IPI Science.

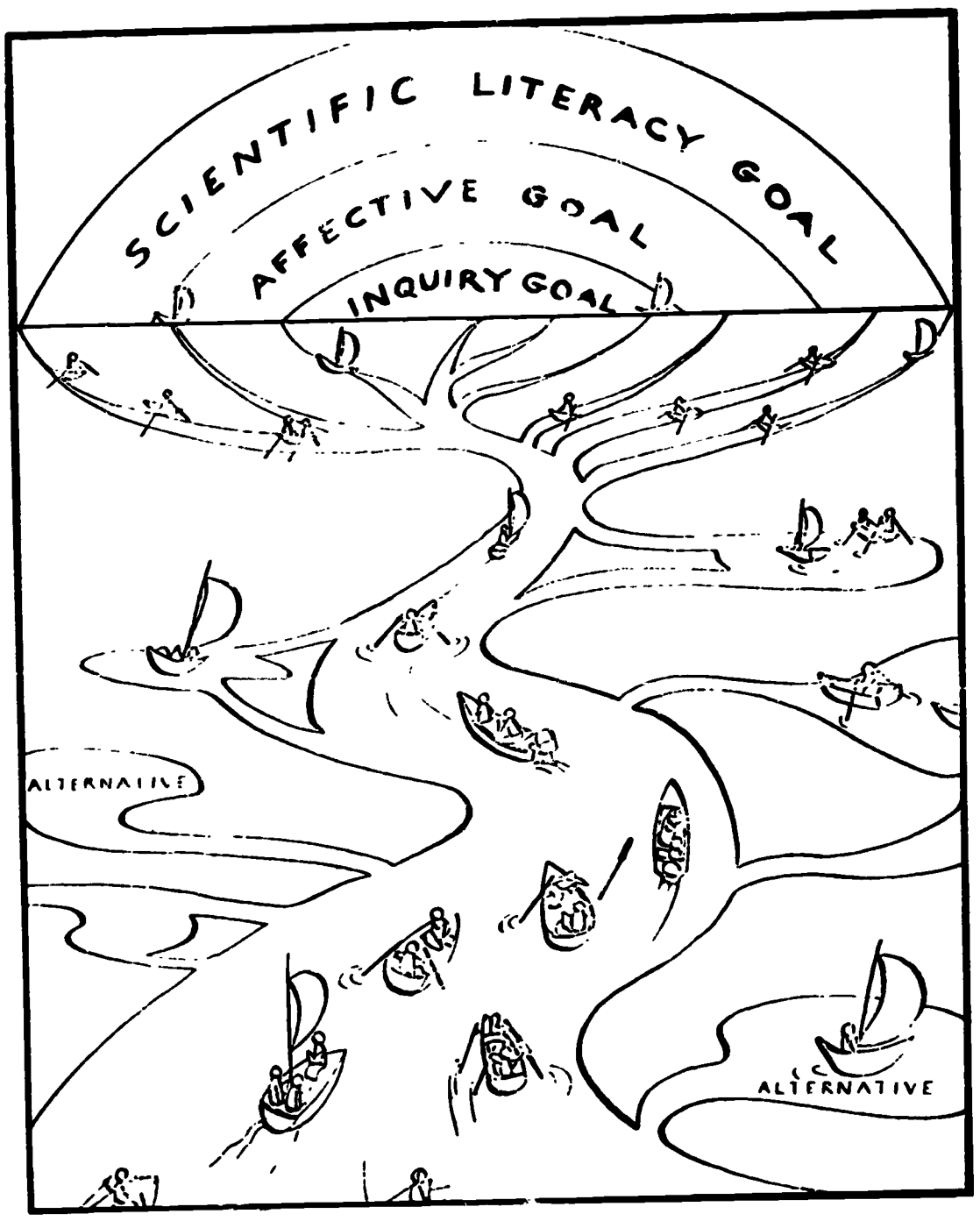
A. Affective Goal
   1. The student enjoys his science learning experiences in school.
   2. The student chooses to pursue independent learning of science outside of school.
   3. The student values science for its contributions to man's intellectual growth and to society.
   4. The student adopts the attitudes which scientists display in their work (the so-called "scientific attitudes") in conducting his own inquiries and in confronting problems.
   5. The student supports well-reasoned positions of scientists on issues where application of scientific knowledge is the primary consideration in resolving the dispute.

B. Inquiry Goal
   1. In performing directed science learning exercises in the laboratory or the field, the student uses correctly the specified processes of scientific inquiry.
   2. The student selects and uses appropriate inquiry processes to carry out investigations into natural phenomena and to solve problems of science.
   3. In confronting problems outside of science, the student selects and uses appropriate inquiry processes to investigate them.

C. Scientific Literacy Goal
   1. The student understands the significant ideas related to the nature of scientific inquiry.
   2. The student understands the significant ideas related to the social aspects of science.
   3. The student understands certain important concepts, principles, and conceptual schemes of science.
   4. The student acquires a basic vocabulary of science words, and he uses this scientific terminology in describing his experiences.

Even though the terminal behaviors are set down here under three separated instructional goals, we do not view the behaviors or the goals separately. They are closely interrelated, and each terminal behavior and instructional goal must be considered in the context of the others. Within the scope of IPI Science, consistent attention is given to all the goals and behaviors and their interactions.

The IPI Science program includes directed group activity. These students are discussing their laboratory experiences with one another and their teacher.



Design of IPI Science

How can a science curriculum be designed so that the student can attain the specified terminal behaviors and can also attain the IPI individualization goals? Though this task is by no means simple, its accomplishment is possible if three conditions are met. These conditions, already adumbrated in the foregoing discussion, are:

(1) The student is not required to have the same learning experiences as every other student or to study all the science units and topics offered in the curriculum.

(2) Provision is made for a common core of science learning, in which every student is expected to achieve mastery.

(3) A rich variety of resources is available, and these resources in alternative instructional materials have functional characteristics that facilitate student self-direction and student co-evaluation.

A curriculum designed in accord with these conditions contains what we call a "Mainstream" and numerous "Alternative Pathways," and this is the curricular design of IPI Science.

The accompanying drawing (see page 29) represents the general design. In IPI Science, the student progresses through time (from bottom to top in the drawing) toward attainment of the three instructional goals. A portion of each student's science study is on the Mainstream, which is the core of science learning for all students, but his experiences increasingly stem off from the Mainstream into many possible Alternative Pathways of science learning which he selects. Some of the Alternative Pathways are on the Mainstream and represent the progress of different students at different rates, or by the use of different instructional media, through the same science content. The other Alternative Pathways, which become more prominent as the student moves up in the curriculum, are off the Mainstream and represent the study of different science content by different students. Also represented in the drawing is the fact that, though IPI Science is an individualized program, only a part of a student's learning is carried out apart from other students.

The Mainstream in IPI Science consists of interlocking threads of ideas that run longitudinally through the years of the curriculum. These threads are three major conceptual schemes, which fall under the Scientific Literacy Goal of IPI Science, and they are entwined in a matrix formed by the terminal behaviors under the Affective Goal and the Inquiry Goal. The major conceptual schemes are drawn from the areas of the Life Sciences, the Physical Sciences, and the Social Aspects of Science. Both on the Mainstream and in the Alternative Pathways, subject matter is presented in the context of the processes of inquiry which give rise to scientific ideas and in the context of the attitudes which IPI Science seeks to develop. Alternative Pathways on the Mainstream and those off the Mainstream may stem from one of the three conceptual schemes or from the interconnections among them. Furthermore, these interconnections are also deliberately highlighted in IPI Science so that a unified picture of science may be built up in the mind of the student.

IPI learning activities are partly or wholly self-directed and self-selected. This girl is advancing her tape recorder for the next part of her lesson.

In this short overview we have sought to present a progress report on the goals, scope, design, and current status of IPI Science[2]. We anticipate the eventual development at LRDC of an individualized science program to serve children in kindergarten through grade nine. Much remains to be done. But, the spirit and daily success of the children in IPI Science at Oakleaf give us every encouragement. ■

FOOTNOTES

1. For more detailed discussions about IPI than can be given in this article, the reader may consult: *Individually Prescribed Instruction*, Education U.S.A. Special Report, National School Public Relations Association, Washington, D.C., 1968; Robert Glaser, "Adapting the Elementary School Curriculum to Individual Performance," in *Proceedings of the 1967 Invitational Conference on Testing Problems*, Educational Testing Service, Princeton, N.J., 1968, pages 3-36; John O. Bolvin, "Implications of the Individualization of Instruction for Curriculum and Instructional Design," *Audiovisual Instruction*, March 1968, *13*, 238-242.
2. For an earlier report on some of the techniques used in IPI Science, see Joseph I. Lipson, "An Individualized Science Laboratory," *Science and Children*, Volume 4, No. 4, December, 1966.